

$B \rightarrow D X$
at
CDF II

Hung-Chung Fang
LBL/UC Berkeley

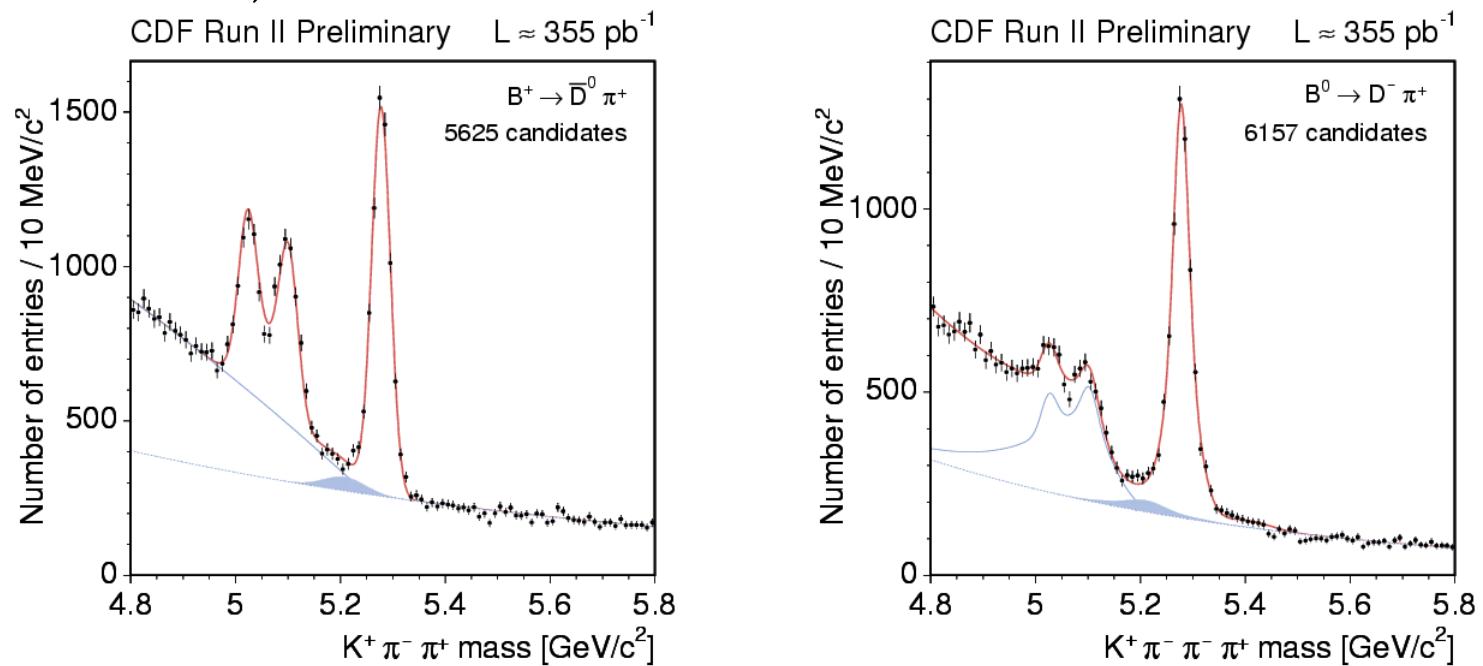
Chicago Flavor Seminar
6 May 2004

Outline

- Current status at CDF
 - B and B_S yields
 - Particle ID: COT dE/dx
- Strategy
- Comparison with B Factories
- Summary and Conclusions

$B \rightarrow D\pi$ yields (mixing – winter conferences)

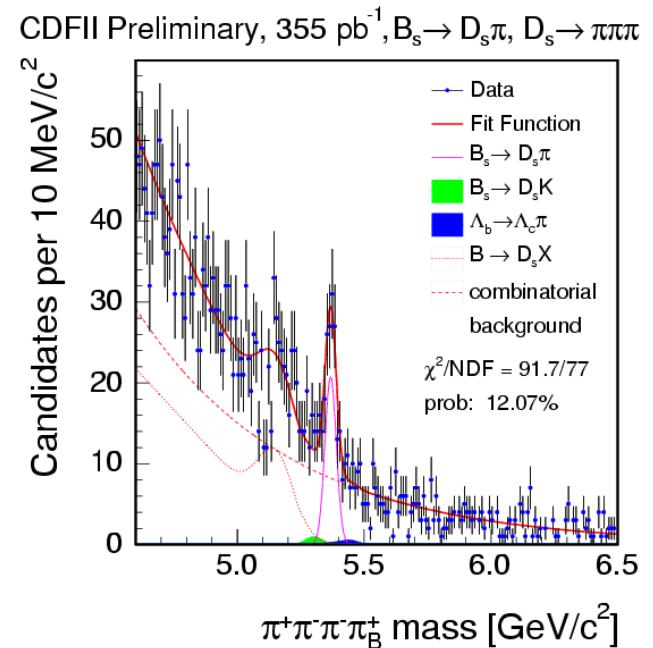
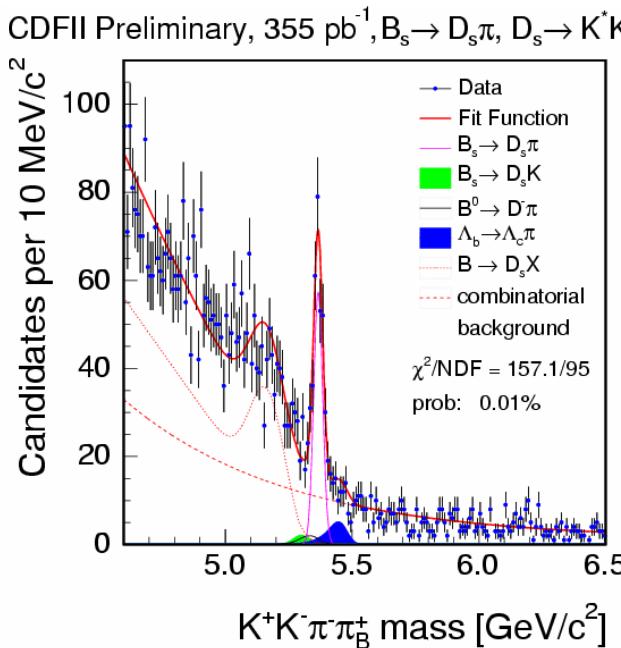
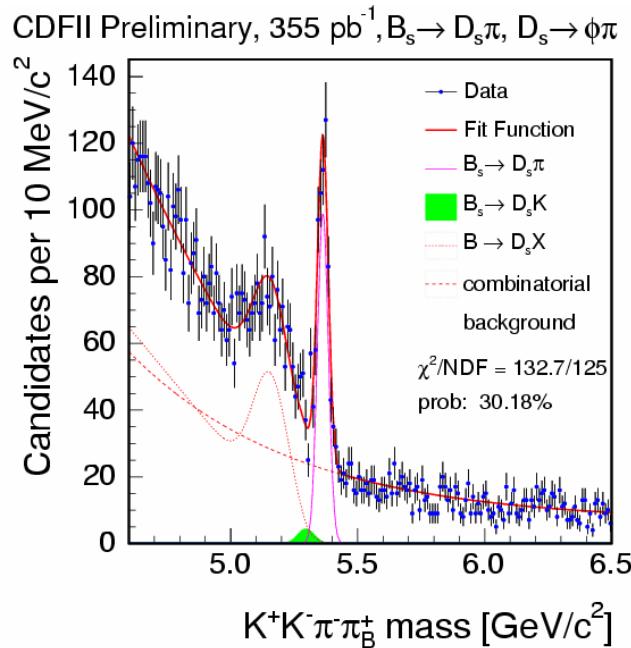
(A. Belloni *et al.*)



$B_s \rightarrow D_s \pi$ yields (mixing – winter conferences)

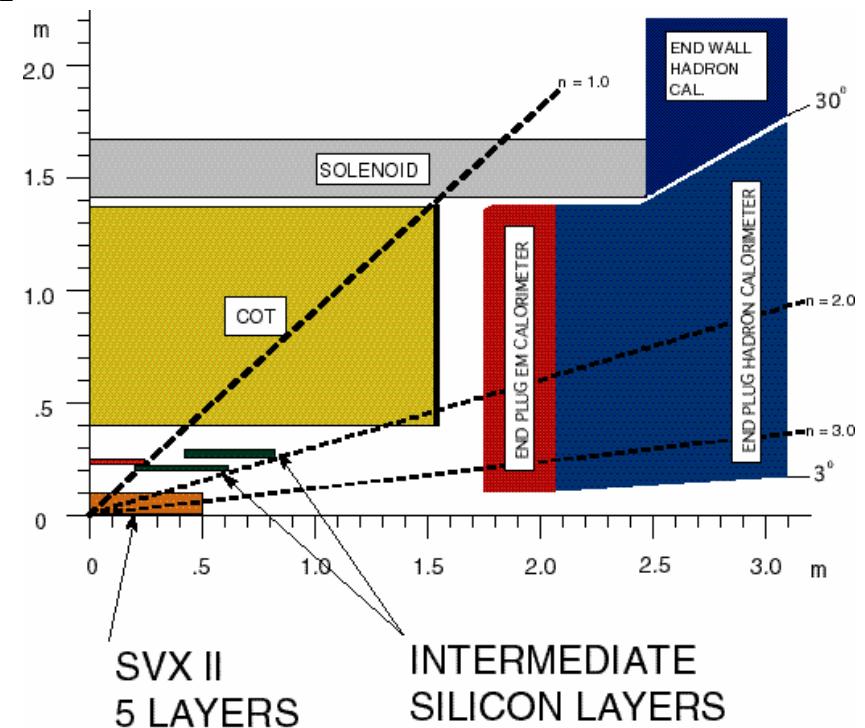
(A. Belloni *et al.*)

| Channel | Yield | S/B |
|--|--------------|-----|
| $B_s \rightarrow D_s \pi, D_s \rightarrow \phi \pi$ | 526 ± 33 | 1.8 |
| $B_s \rightarrow D_s \pi, D_s \rightarrow K^{*0} K$ | 254 ± 21 | 1.7 |
| $B_s \rightarrow D_s \pi, D_s \rightarrow \pi \pi \pi$ | 116 ± 18 | 1.0 |



The Central Outer Chamber (COT) at CDF II

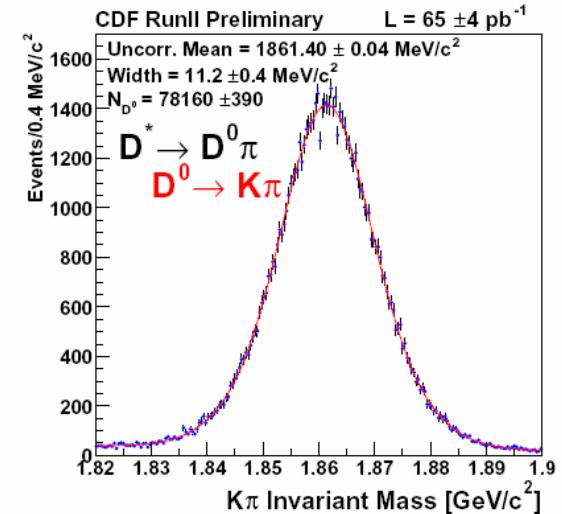
- Multiwire proportional drift chamber
- Fast Ar-Et-CF₄ gas (50:35:15)
max. drift time = 100 ns
- 30,240 sense wires
- 8 superlayers / 96 layers
- At R=40~137 cm
- 310 cm long:
full coverage to $|\eta| = 1$
- Digital pulse width encodes
 dE/dx info ← ← ←



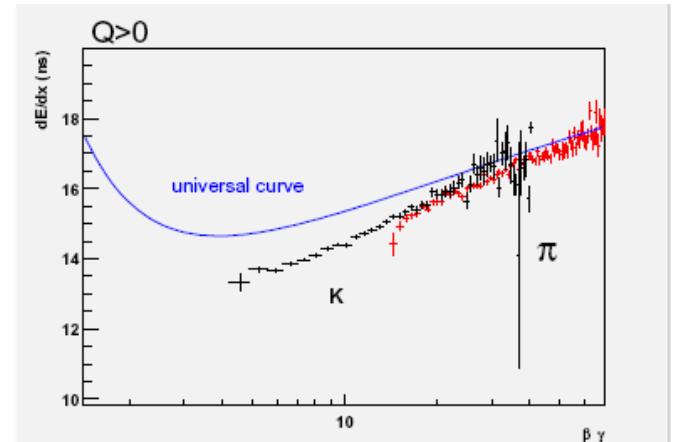
Particle ID with the COT: dE/dx corrections

- dE/dx logarithmically encoded in pulse width
- Latest in a series of dE/dx correction attempts
- For example: take $p_T > 2$ GeV π/K from $D^{*+} \rightarrow D^0 [\rightarrow K^-\pi^+] \pi^+$ decays
- Correct for
 - Chamber pressure
 - Dip angle, etc.
- Fit to Bethe-Bloch curve

$$dE/dx = \frac{1}{\beta^2} \cdot (c_1 \cdot \log \frac{\beta\gamma}{b + \beta\gamma} + c_0) + a_1(\beta - 1) + a_2(\beta - 1)^2$$

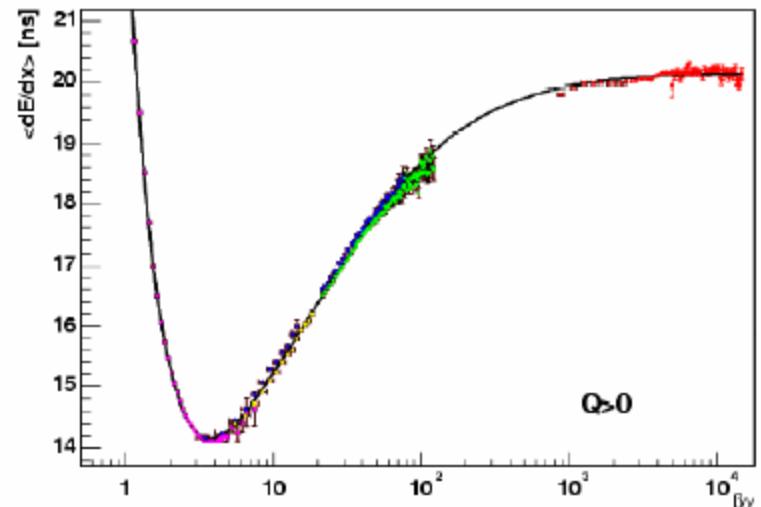
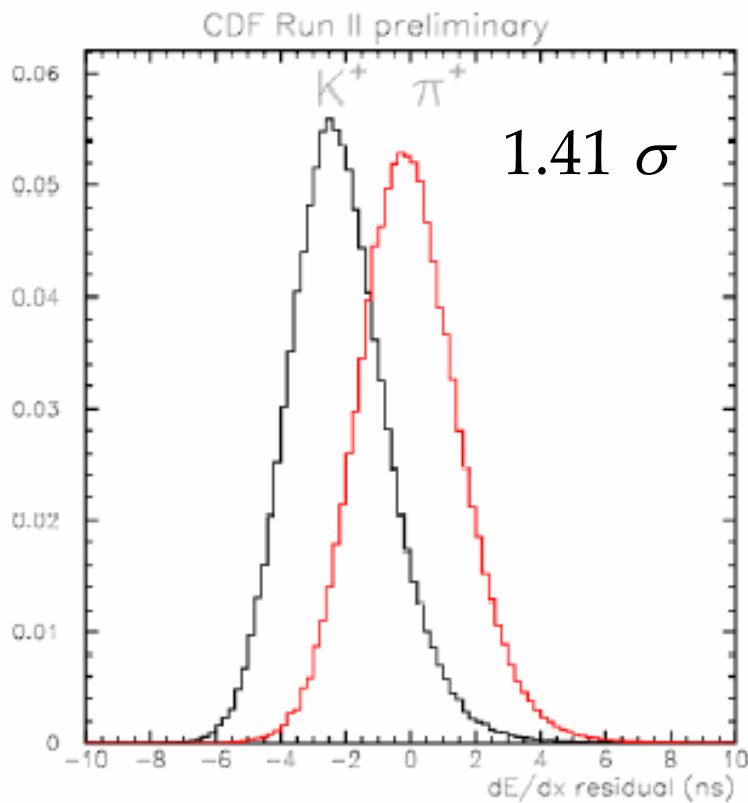


(CDF COT-dE/dx calibration group)



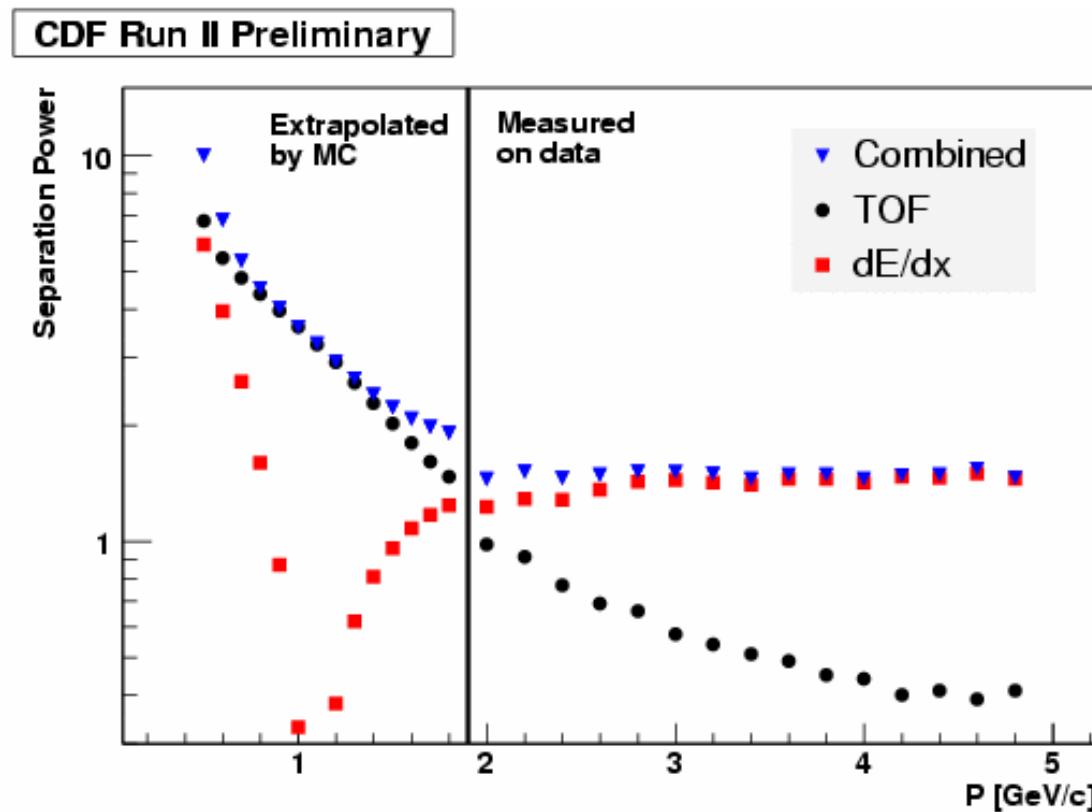
K - π separation after dE/dx correction

(CDF COT- dE/dx
calibration group)



K - π separation: COT dE/dx & Time of Flight

(P. Squillaciotti, G.Punzi)



Strategy

Baseline measurement: $BR(B^- \rightarrow D^0 K^-)/BR(B^- \rightarrow D^0 \pi^-)$

Also study $B^- \rightarrow D_{CP+} \pi^- / K^-$, $D_{CP+} \rightarrow K^+ K^- / \pi^+ \pi^-$ -- challenging analysis

- Optimize cuts for DK significance
 - Beat down combinatorial background: isolation cut, etc.
 - Primary vertex pointing, mass constraints
 - Understand tail of partially reconstructed modes at DK mass
- Incorporate particle ID in likelihood fit
 - $D_f K$ optimal point likely to be in regime where dE/dx is useful
 - $D_{CP} \pi / K$ optimal point may require TOF
- Mass/kinematics+ dE/dx maximum likelihood fit

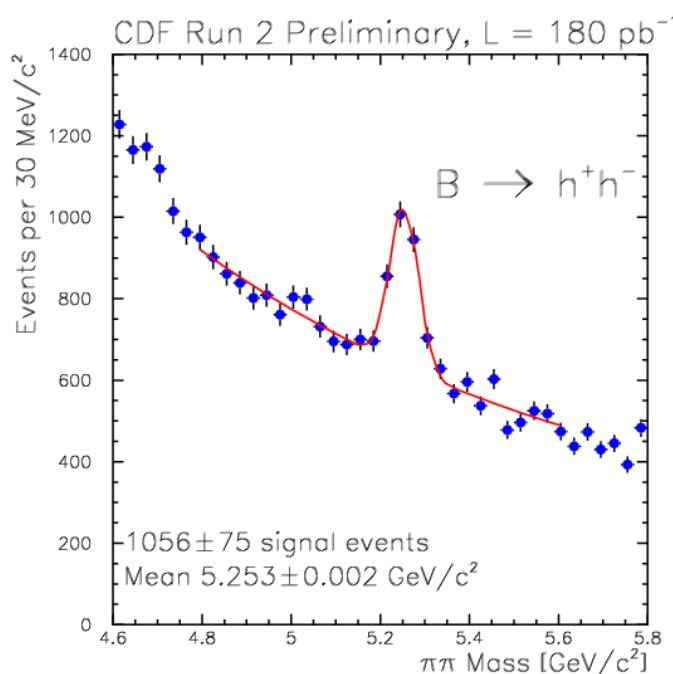
Search for $B_s^0 \rightarrow D_s^- K^+ / D_s^+ K^-$ (not yet seen), $D_s^- \rightarrow \phi \pi^- / K^* K / 3\pi$, etc.

- Interference effects
- Time integrated asymmetry ~ 0 for SM
- Very long term (**LHCb** ?): time-dep. asym. gives γ

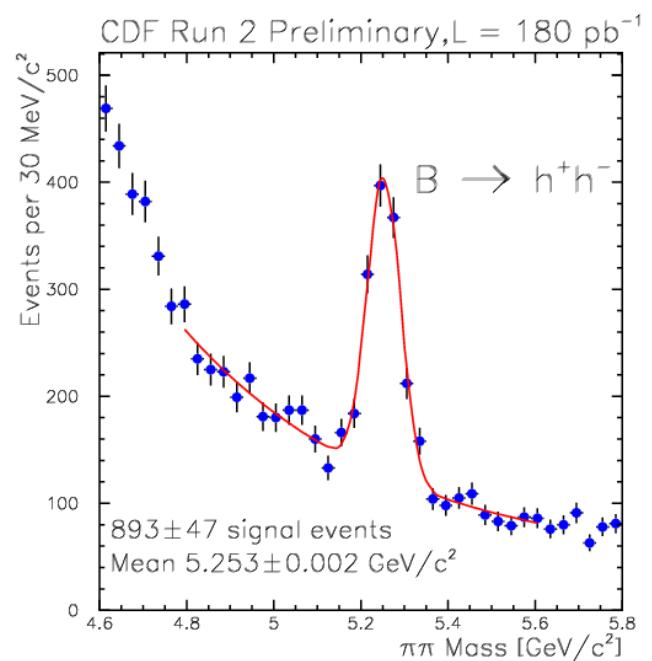
Kinematics: isolation of B candidate

An example of kinematics cuts in $B_{(S)} \rightarrow h^+h^-$

(CDF Italian group)

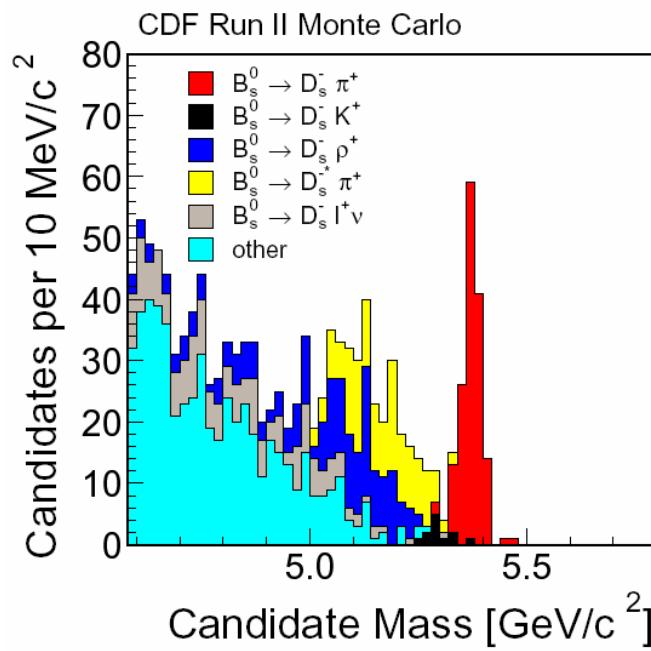
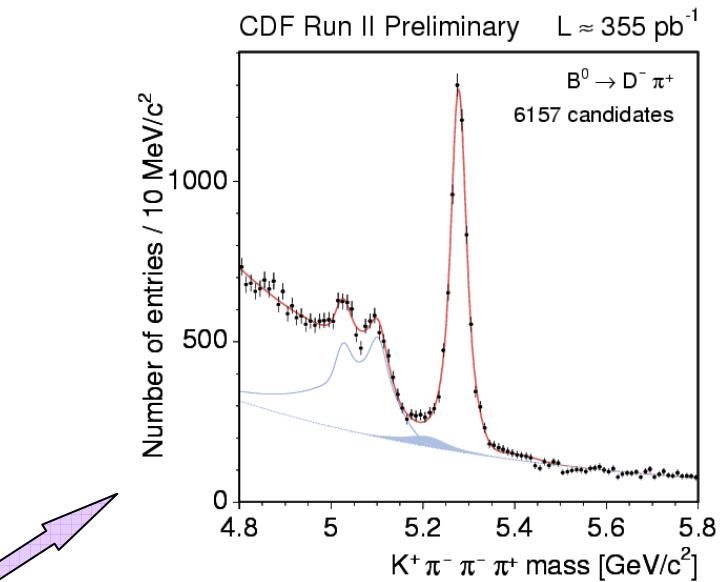
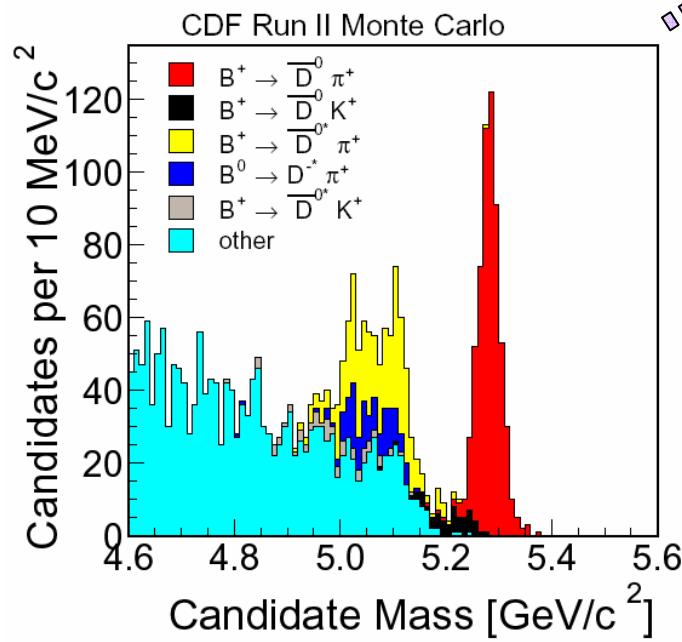


sig. eff. ~85%
bkgd. rej. 5x



Background studies

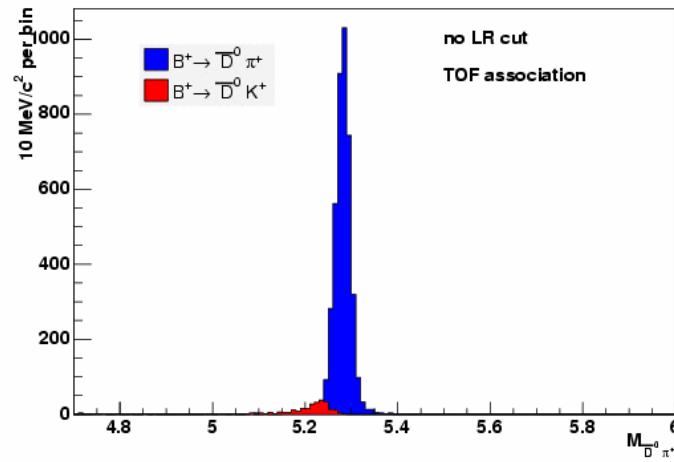
$B^- \rightarrow D_{(S)}^0 X$ Monte Carlo (I. Furić)



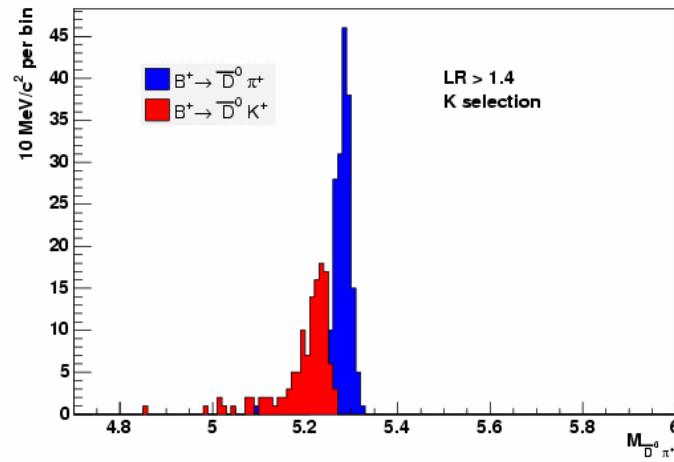
$B \rightarrow D K$ vs. $B \rightarrow D \pi$: Particle ID

(P. Squillaciotti, G.Punzi)

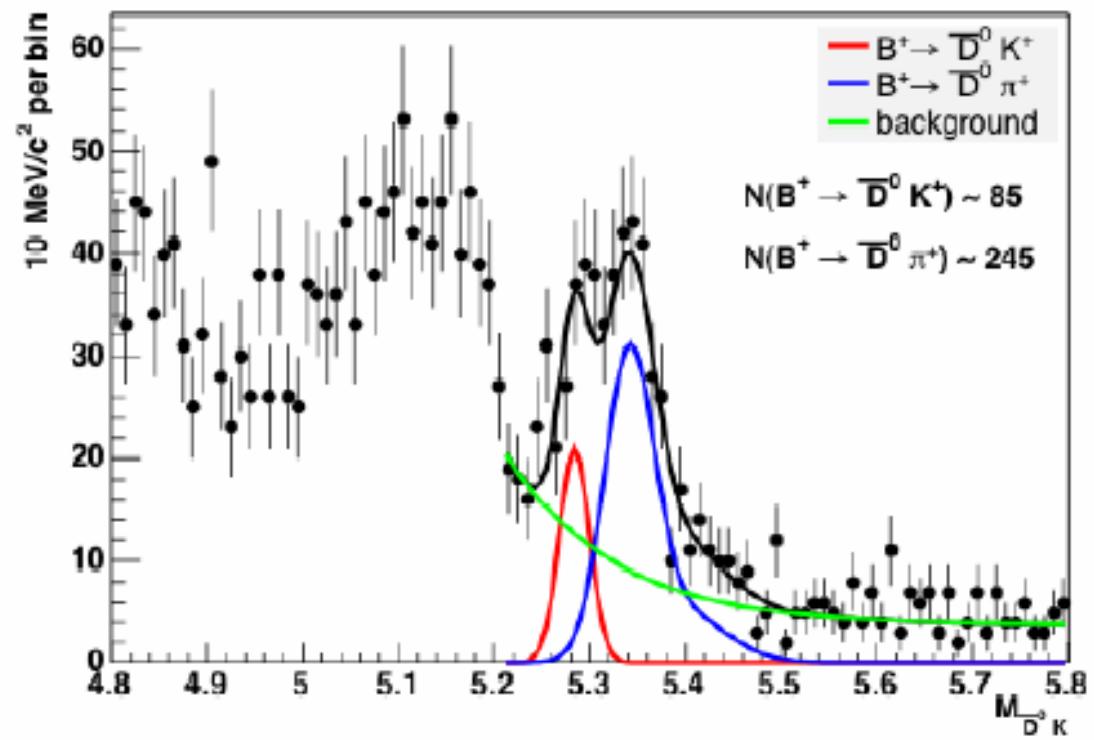
CDF Run II Monte Carlo



CDF Run II Monte Carlo



CDF Run II Preliminary

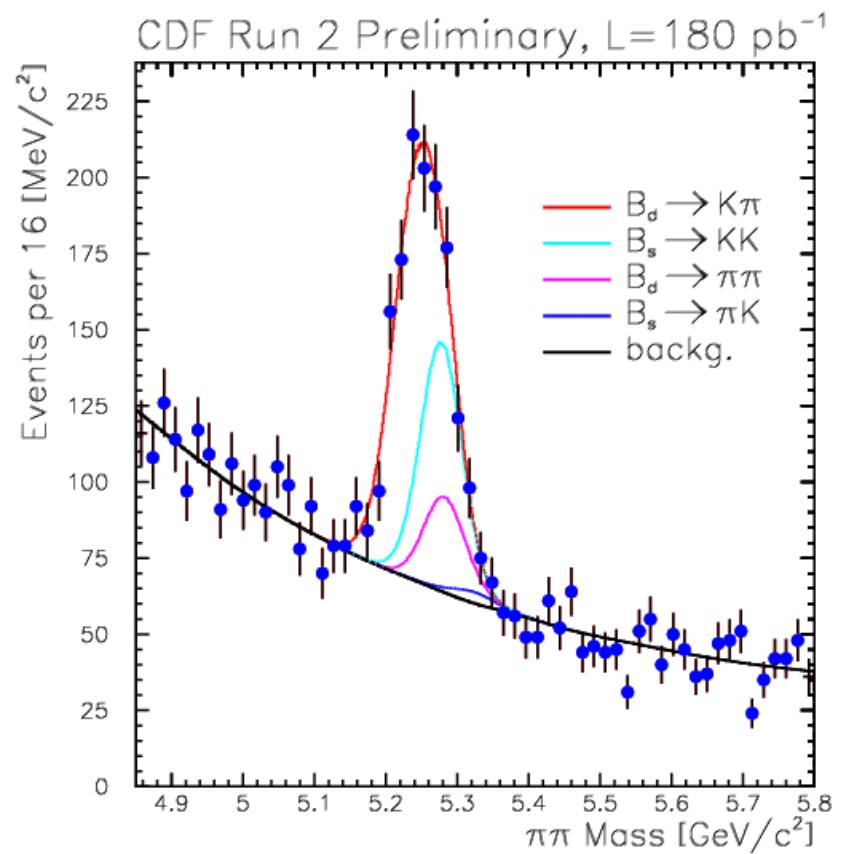


An example at CDF:

$B_{(S)} \rightarrow h^+ h^-$

(D. Tonelli *et al.*)

- Combines in a single likelihood fit –
 - Kinematic variables
 - Particle ID: dE/dx
 - Mass distributions



Direct CPV in $B \rightarrow D_{CP} K$: other experiments

- **BaBar:** hep-ex/0408082

$$D_{CP+}^0 \rightarrow K^+ K^-, \pi^+ \pi^-$$

$$D^0 \rightarrow K^- [\pi^+, \pi^+ \pi^0, \pi^+ \pi^- \pi^+]$$

- **Belle:** BELLE-CONF-0443

$$D^0 \rightarrow K^- \pi^+$$

$$D_{CP+}^0 \rightarrow K^+ K^-, \pi^+ \pi^-$$

$$D_{CP-}^0 \rightarrow K_S^0 [\pi^0, \phi, \omega, \eta, \eta']$$

- **CLEO:** hep-ex/0302026

$$D^0 \rightarrow K^- [\pi^+, \pi^+ \pi^0, \pi^+ \pi^- \pi^+]$$

| | | |
|-----------|---------------------------------------|----------------|
| A_{CP+} | = $0.07 \pm 0.14(stat) \pm 0.06(sys)$ | (Belle) |
| A_{CP+} | = $0.40 \pm 0.15(stat) \pm 0.08(sys)$ | (BaBar) |
| R_{CP+} | = $0.98 \pm 0.18(stat) \pm 0.10(sys)$ | (Belle) |
| R_{CP+} | = $0.87 \pm 0.14(stat) \pm 0.06(sys)$ | (BaBar) |

| | | |
|-----------|--|----------------|
| A_{CP-} | = $-0.11 \pm 0.14(stat) \pm 0.05(sys)$ | (Belle) |
| A_{CP-} | = $0.21 \pm 0.17(stat) \pm 0.07(sys)$ | (BaBar) |
| R_{CP-} | = $1.29 \pm 0.16(stat) \pm 0.08(sys)$ | (Belle) |
| R_{CP-} | = $0.80 \pm 0.14(stat) \pm 0.08(sys)$ | (BaBar) |

| | | |
|-----|---|----------------|
| R | = $(8.31 \pm 0.35(stat) \pm 0.20(sys))\%$ | (BaBar) |
| R | = $(7.7 \pm 0.5(stat) \pm 0.6(sys))\%$ | (Belle) |
| R | = $(9.9 \pm 1.3(stat) \pm 0.7(sys))\%$ | (CLEO) |

Yield comparisons

- Statistics for the latest measurements:

| Experiment | $B \rightarrow D\pi$ | | | $B \rightarrow DK$ | | | int. lum. |
|----------------------|----------------------|------|------|--------------------|------|------|-------------------------|
| | flavor | CP + | CP - | flavor | CP + | CP - | |
| BaBar | 11900 | 1400 | 1300 | 900 | 90 | 76 | 214e6 |
| Belle | 19300 | 2200 | 2400 | 1000 | 110 | 170 | 274e6 |
| CLEO(II+III) | ? + 380 | - | - | ? + 80 | - | - | 9+6(fb^{-1}) |
| CDF II (est.) | 6000x2 | ~450 | - | ~450 | ~50 | - | 355(pb^{-1}) |

- Some CDF numbers my guesstimate!
 - $B \rightarrow D\pi$: ~15 pb (cp. BaBar: 180 fb)
 - Reconstruct $D^0 \rightarrow K^-\pi^+\pi^-\pi^+$ in addition to $D^0 \rightarrow K^-\pi^+$
 $\Rightarrow \sim 2x$ statistics

Summary statistics for CDF (data thru fall 2004)

| channel | $\sigma(\text{pb})$ | yield in 355 pb^{-1} | signif.* (no dE/dx) | signif. * with dE/dx |
|------------------------------|-----------------------|--|------------------------|-------------------------|
| $B \rightarrow D_f \pi$ | 15×2 | 6000×2 | <i>Large</i> | - |
| $B \rightarrow D_f K$ | $\sim 1 \times 2$ | $\sim 500 \times 2$ | ~ 5 | ~ 7.5 |
| $B \rightarrow D_{CP^+} \pi$ | ~ 1 | ~ 500 | > 15 | - |
| $B \rightarrow D_{CP^+} K$ | ~ 0.1 | ~ 50 | $\sim 1^{**}$ | $\sim 2^{**}$ |
| $B_s \rightarrow D_s \pi$ | 1×1.8 | 500×1.8 | > 30 | - |
| $B_s \rightarrow D_s K$ | $\sim 0.1 \times 1.8$ | $\sim 50 \times 1.8$ (interference effects unknown) | ?? | ?? |

*Statistical significances represent my own wild guesses for a reasonable (non-optimal) set of cuts – no guarantees express or implied!

** These guesses do not include effect of particle ID on D reconstruction

Conclusions

- Modes with no neutrals competitive with B factories
- More data coming in – amount will depend on Tevatron luminosity and CDF trigger strategy